REMARKS

Summary of Amendments

Independent claims 1 and 5 have been amended to incorporate the compressive stress limitation of claims 3 and 7, respectively, and to positively set forth how this compressive stress is deliberately imparted to the claimed tool-coating film.

Claims 3 and 7 have consequently been cancelled, and the claim 1 amendments have necessitated an editorial amendment to claim 2.

Claims 17 and 18 have been amended as claim 1 has to positively set forth how the compressive stress is deliberately imparted, and to limit the PVD method to cathodic-arc deposition.

Claims 19 and 20 have been amended as claim 5 has to positively set forth how the compressive stress is deliberately imparted, and further, in claim 19, to include the claim 6 limitation, and in claim 20, to limit the PVD method to cathodic-arc deposition.

Rejections under 35 U.S.C. § 102

Claims 1-4, 10-12, 17 and 18; Waldenstrom et al. '479

Claims 1-4, 10-12, 17 and 18; Söderberg et al. '318

Claims 1-4, 10-12, 17 and 18 stand rejected under 35 U.S.C. § 102(e) as being anticipated by U.S. Patent No. 6,221,479 to Waldenstrom et al., and under 35 U.S.C. § 102(b) as being anticipated by U.S. Patent No. 5,942,318 to Söderberg et al.

Under sections 2 and 3 of the Office action, it is alleged that Waldenstrom et al. and Söderberg et al. disclose certain of the features set forth in the rejected claims, and it is added, "The claimed stress in the coating is considered inherent to the produced coating."

To the contrary, Applicants state that in the present invention, since the film coating the cemented carbide tool is formed by physical vapor deposition, compressive stress is deliberately imparted to the coating.

Although prior to the embodiments set forth in the present specification, PVD is discussed only with regard to the hard-carbon film coating, in the explanation of the embodiment examples and as set forth in the corresponding tables, vapor-deposition is the method employed to coat the tools with a film of a film of (Ti, Cr, V, Si, or Al) + (C or N).

Applicants note that in the PVD technique, negative voltage is applied to the substrate and a coating is deposited onto the substrate as plasma generated inside is drawn into the deposition chamber. Therefore, the incident energy of the plasma ions forming the coating introduces point defects into the film, on account of which strain is left in the film's crystal lattice, and as a result compressive stress remains in the film.

Further, Applicants add that residual stress in the present invention is generated by the crystal lattice—and the strain in the lattice—produced in a PVD deposition process, and thus depends on the deposition conditions (gas pressure, substrate bias voltage, deposition temperature, etc.).

Applicants also note that in films having the same composition, those that are thicker will have a greater stress. Further, the incident energy of the ions forming the coating film is related to the atomic size (ionic diameter) and atomic weight of the elements constituting the film, so naturally, changing the film composition will alter the strain introduced into the crystal lattice of the deposited coating, and as a result the residual stress will vary.

Accordingly, claims 1, 17 and 18 have been amended to recite that the claimed film is a compound of elements "in given elemental proportions," coated onto the tool base material "to a given thickness" (claims 1 and 17) or to a thickness within a specifically recited range (claim 18), and to recite that the claimed film coating is vapor-deposited onto the base material,

> under reaction-gas pressure, base-material bias voltage, and deposition-temperature conditions [that], together with said given thickness and said given elemental proportions, are predetermined so as to impart a compressive residual stress of 0.1 GPa or more and 8 GPa or less to said compound thin film.

Waldenstrom et al. and Söderberg et al. are silent as to residual/internal or compressive stress in tool coatings. Accordingly, it is respectfully submitted that Waldenstrom et al. and Söderberg et al. do not disclose, let alone teach or suggest, a surface-coated machining tool having the features recited in claims 1, 17 and 18, in which the coating film in particular possesses a deliberately imparted stress as now recited in these claims.

Claims 5-9, 13-16, 19 and 20; Ederyd et al. '948

Claims 5-9, 13-16, 19 and 20 stand rejected under 35 U.S.C. § 102(b) as being anticipated by U.S. Patent No. 5,718,948 to Ederyd et al.

Ederyd et al. is directed to the coating of cemented carbide tools "for percussive, rotary crushing and cutting rock drilling" (column 3, lines 33-34). Although Ederyd et al. never explicitly mention the scale of their tools, in the examples set forth therein, the average wear on the tested buttons, bits, and tips ranges from 1.1 mm to 4.8 mm.

The present invention, in contrast, is directed to coated *machining* tools—in particular, machining tools for processing printed circuit boards. Such tools are discussed in the Background of the present specification: PCB router cutters of 1.6 mm or less in diameter, and PCB miniature drills of 0.2 mm or less in diameter—dimensions that are on the order of, and indeed less than, the *wear* on the tools of the Ederyd et al. examples. Hence, the tools to which the present invention is directed are on a scale that, likely an order of magnitude lower, clearly differs dramatically from that of the tools to which the Ederyd et al. disclosure is directed.

In column 2, lines 1-8, Ederyd et al., discuss the problems of getting diamond coatings to adhere to cemented carbide substrates, mentioning that

> [f]ormation of voids and non-diamond material at the coating/substrate interface in combination with high compressive stresses in the coating are believed to be the main reason for poor adhesion. Formation of high residual stresses (compressive) is partly due to the low coefficient of thermal expansion of diamond.

Thus, Ederyd et al. appear to teach away from high compressive stress in diamond coating on carbide tools—likely because those tools are on a scale suitable "for percussive, rotary crushing and cutting rock drilling"—whereas the hard carbon film of the present invention—on tools scaled to precision machining of circuit boards for miniaturized electronic devices—has a compressive residual stress of 0.1 GPa to 8 GPa.

Moreover, an essential aspect of the Ederyd et al. disclosure is altering the content of binder phase in the bodies of the coated tools to set up "compressive stresses in the cemented carbide in the zone nearest to the coating interface." An added result is that "[t]he reduced coefficient of thermal expansion in the surface zone of the cemented carbide due to its high content of hard constituents . . . leads to an improved thermal matching between the coating and cemented carbide body."

Accordingly, as far as stress is concerned, Applicants note that Ederyd et al. address the problem of controlling residual stress originating in the thermal expansion coefficients of the substrate and the film. In the present invention, in contrast, compressive stress is deliberately imparted to the hard-carbon film coating as recited in claims 5, 19 and 20.

Applicants note that to reject claims 5-9, 13-16, 19 and 20 as being disclosed in Ederyd et al., the assumption would be that, as set forth in the examples and in the first three-and-a-half paragraphs of column 2 of Ederyd et al., the subject matter of these claims includes a diamond film produced by CVD (rather than PVD, as is the case with the embodiments set forth in the present specification). Applicants go on to note that from the examples in Ederyd et al. it is clear that in ramping up the deposition temperature to 800°C or more, and after film deposition is complete, ramping the substrate down to room temperature, stress is produced in the coating films of Ederyd et al. Consequently, Applicants add, the Ederyd et al. method is quite significantly dependent on the temperature at which the film is deposited and from which it goes through a cooling process—in other words, the method is dependent on the temperature environment of the sample.

In contrast, as set forth above with regard to the rejections made over the Waldenstrom et al. and Söderberg et al. disclosures, Applicants point out that residual stress in the present invention is generated by the crystal lattice—and the strain in the lattice—produced in a PVD deposition process, and thus depends on the deposition conditions (gas pressure, substrate bias voltage, deposition temperature, etc.).

Accordingly, claims 5, 19 and 20 have been amended to recite that the claimed hard carbon film is coated onto the tool base material "to a given thickness" (claims 5 and 20) or to a thickness within a specifically recited range (claim 19), and to recite that the claimed film coating is deposited onto the base material by a physical vapor deposition method in which graphite is made a raw material, and

> under reaction-gas pressure, base-material bias voltage, and deposition-temperature conditions that, together with said [given] thickness, are predetermined so as to impart a compressive residual stress of 0.1 GPa or more and 8 GPa or less to said compound thin film.

It is respectfully submitted that Ederyd et al. do not disclose, let alone teach or suggest, a surface-coated machining tool having the features recited in claims 5, 19 and 20, in which the coating film in particular possesses a deliberately imparted stress as now recited in these claims.

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For the foregoing reasons, and based on the amendments made herein to the pending claims, Applicant courteously urges that this application is in condition for allowance. Reconsideration and withdrawal of the rejections is requested. Favorable action by the Examiner at an early date is solicited.

Respectfully submitted,

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